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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

REPORT

ON

EFFECTS OF EXPERIMENTAL TREATMENTS

ON

BROOD OF DENDROCTONUS PONDEROSAE

By
M. W. Blackman,
Specialist in Scolytidae
U.S. Bureau of Entomology
October 29, 1926

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GOVERNMENT PRINTING OFFICE

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I. LOG CUT OUT AND LAID TIGHT ON GROUND (SOURING EXPERIMENTS)

"SOURING" EXPERIMENTS OF 1925-'26

The "souring" experiments started in September, 1924, on examination during July 1925 seemed to give some promise of success as a control measure. However, the data taken at that time was not of such a character as to lend itself readily to exact conclusions which could be expressed mathematically. However, as the method gave some promise of results the experiments were repeated in the fall of 1925. Briefly the treatment consists in felling the infested trees, cutting out the infested length of the trunk, and laying this flat on the ground. The 1924 treatments had seemed to result in a soured or fermented condition of the sap, which produced an early mortality of the brood - presumably during the few weeks intervening between the time of felling and the advent of the season of snows.

In the second series of experiments, 26 trees were felled and treated at dates varying from August 18 to September 28, 1925. Two of these trees on later examination proved to have been insufficiently infested and the data on them was discarded. An early rather superficial examination was made of 17 of the trees June 10 and 11, 1926, and the following general data:

Square feet i.b. examined in 17 trees	120.5
Total brood in 120.5 sq. ft. examined	652.0
Average brood in per sq. ft. all trees examined (treated August 18 - September 28)	5.41
Average brood in trees treated August 18-24 (per sq. ft.) . .	0.93
" " " " " August 18-31 " " " . . .	5.87
" " " " " September 7-28 " " " . . .	7.26
" " " " " August 31-Sept.28" " " . . .	7.93

This preliminary data shows the same general tendency as the more detailed data from the later examination and will not be further discussed at this time.

June 23 to 26 all of the bark was carefully removed from the S - series of trees, the brood was preserved in alcohol and an accurate count made later. At this time also the attacks on each tree were recorded and the infested area inside the bark was computed. The data for each tree is summarized in the accompanying table.

BROOD COUNTS - ENTIRE TREES - SOURING EXPERIMENTS -
INFESTED LENGTH CUT OUT AND LAID TIGHT ON GROUND - 1925.

No.	Locality	Date of Treatment	Date of Spotting	DBH	Length Infested	Crown	Increment last half inch	total attacks	Attacking beetles	Total brood	excess or deficiency of brood	Per Square Foot: Attack	Beetles attacking	Brood	Excess or deficiency
		1925	1925												
S-1	East Ridge West Slope	8/18	8/6	26"	42'	Heavy	10	1436	2872	174	-2698	6.67	13.34	0.81	-12.55
S-2	East Ridge: Top	8/18	8/12	13"	46'	M.H.	14	492	984	20	-964	5.02	10.04	0.20	- 9.83
S-3	West Ridge: So. Slope: Near top	8/22	8/17	22"	46'	V.H.	23	715	1430	249	-1181	3.61	7.22	1.25	- 5.96
S-4	West Side near Trap-Trees.	8/24	8/16	18"	42'	Med.	15	535	1070	37	-1033	5.34	6.68	0.23	- 6.45
S-5	2nd Ridge West	8/31	8/28	18"	66'	Med.	9½	1041	2082	12	-2070	4.98	9.96	0.05	- 9.91
S-6	" "	8/31	8/28	12"	51'	M.L.	21	453	906	87	-819	4.44	8.88	0.85	- 8.03
S-7	" "	8/31	8/15	15"	48'	Med.	10	663	1326	948	-378	6.63	13.26	9.48	- 3.78
S-8	" "	8/31	8/21	11"	27'	M.L.	28	341	682	689	+7	5.59	11.18	11.29	+ 0.11
S-9	" "	8/31	8/21	15"	42'	M.L.	10	383	766	2306	+1540	4.25	8.50	25.62	+17.11
S-10	West Side near Trap Trees:	9/7	8/24	18"	20'	Med.	24	182	364	620	+256	2.16	4.32	7.38	+ 3.04
S-11	" "	9/7	8/16	12"	20'	M.L.	30	87	174	600	+426	1.71	3.42	11.77	+ 8.35
S-12	" "	9/7	8/16	13"	24'	Med.	29	104	208	45	-163	1.57	3.14	0.69	-2.47
S-13	" "	9/7	8/16	14"	28'	Med.	15	215	430	456	+26	2.50	5.00	5.30	+ 0.30

BROOD COUNTS - ENTIRE TREES - SOURING EXPERIMENTS - (Continued)
INFESTED LENGTH CUT OUT AND LAID TIGHT ON GROUND - 1926.

No.	Locality	Date of Treatment	Date of Spot-ting	Length In- fested	DBH Crown	Increment last half inch	Total attacks	Attacking beetles	Total brood	Excess or deficiency of brood	Per Square Foot: Beetles attacking	Per Square Foot: Brood	Per Square Foot: Excess or Deficiency
S-14	(West Side near) Trap Trees: 23rd Ridge)	1925 9/7	1925 8/19	12" 20'	V.L.	.57	195	386	784	+398	3.44	6.88	+7.12
S-15	East-west Slope)	9/14: 8/12		17" 50'	heavy	10.	1009	2018	142	-1866	7.94	15.86	1.11 -14.69
S-16	" "	9/14	8/27	10" 18'	"	15.	81	162	24	-138	2.55	5.06	0.75 -4.31
S-17	" "	9/14	8/27	15" 24'	M.H.	10.	265	530	303	-127	3.23	6.46	3.69 -2.77
S-18	" "	9/14	8/27	10" 14'	M.L.	32	92	184	138	-46	3.54	7.08	5.30 -1.78
S-20	" "	9/21	8/29	15" 18'	M.L.	15	127	254	8	-246	2.27	4.55	0.14 -4.39
S-21	" "	9/21	Aug. Late	13" 34'	L.	19	482	964	308	-656	5.69	11.60	3.71 -7.90
S-23	East Ridge near Exp.	9/28	8/18	13" 42'	M.L.	15	454	908	1019	+111	5.40	10.80	12.13 +1.32
S-24	" "	9/28	8/19	10" 28'	L.	23	194	388	263	-115	4.41	8.82	5.97 -2.61
S-25	" "	9/28	8/13	11" 36'	M.H.	26	275	550	1056	+506	5.09	10.18	19.55 +9.37
S-26	" "	9/28	8/18	10" 20'	M.L.	31	198	396	402	+6	4.35	8.70	8.83 +0.13

Total sq. ft. 2208.94

Totals	10017.	20034	10690	9344	
Average			4.98	9.97	4.64 5.13

+ — = Excess brood - i. e. brood more numerous than attacking beetles.
— — = Deficient Brood - i.e. " less " " " " " "

In the foregoing table the stage of the brood is not recorded but all of such data are recorded in the original notes. This can be summarized for the twenty-four trees as follows:

Larvae	5,679 - - - -	54.00%
Pupae	3,247 - - - -	30.85%
Young adults	1,596 - - - -	15.15%
Total brood	10,690 - - - -	100. %

On comparing this with the brood in standing trees studied one week earlier where the condition of the brood stood: - larvae - 30.35%, pupae 60.91% and young adults 8.73%, it is interesting to note that the treated trees show a greater percentage of young adults than the standing trees but a much smaller percent of pupae (only about half as many) and nearly twice as many larvae. Thus the tendency of the treatment was apparently a retarding one. This retarding of the brood may have been due to the difference in food value between the scored and normal inner bark, but more likely was due to a difference in temperature conditions. The down trees would remain covered with snow for a week or so in the Spring after growth had been resumed in the standing trees. But the portion of the brood in the uppermost section of the bark would be stimulated by the greater amount of solar heat. Thus all of the brood in the "S-trees" would be retarded in early spring; The majority of them would continue to be retarded later; but a small percentage of the brood would, as soon as the snow was melted off, be stimulated by the greater amount of solar heat absorbed by the down trees.

CORRELATION OF CONDITION OF BROOD WITH CROWN CHARACTER OF TREES

	V.heavy	heavy	Med.heavy	medium	Med. light	light	Very light
24 Trees Studied	1	3	3	6+	8	2	1
9 Trees with excess brood	0	0	1	2	+5	0	1
15 Trees with deficient brood	1	3	2	+4	3	2	0

The trees are distributed as regards character of the crown as shown above. The mean crown character of all of the trees treated lies just within the medium class, but nearer the medium-light condition. In trees with excess brood the mean crown lies in the medium-light class with no trees having a heavy or very heavy crown. In trees with deficient brood the mean crown is nearly exactly in the center of the medium class with no trees having a very light crown.

CORRELATION OF CONDITION OF BROOD WITH INCREMENT

An increment of last half inch radius in all trees treated - - - - -	19.4
" " " " " " " " Trees with excess brood - -	23.9
" " " " " " " " " " deficient " - - -	17.00

It would appear from the preceeding two tables that the better brood in the S-series of trees of the 1925 treatment are found in the more slowly growing trees having a crown lighter than the average. The same condition existed in standing trees as is shown elsewhere in this report. Such trees at the time of felling and treating would contain less sap and perhaps would undergo a smaller amount of fermentation. It would seem that when the felled trees are treated by cutting out the infested length the sap is "trapped" in the cut out log and if conditions are right immediately begins to "sour". In a rapidly growing tree the larger amount of sap would ferment more readily while in a slowly growing tree the conditions would be more nearly comparable to a tree with the foliage still functioning.

CONDITION OF BROOD IN RELATION TO NUMBER OF ATTACKS PER SQUARE FOOT.

Several of the trees with deficient brood (such as S-12, S-16 and S-20) and two of them with excess brood (such as S-10 and S-11) were very low in number of attacks and the beetle would probably have been "pitched out" had the tree not been cut. These reduce the average attack per square foot, but as such trees occur in both groups, they about balance each other and their occurrence does not materially alter the general conditions shown.

Average attacks per sq. ft. in 24 trees studied - - - - - - - -	4.98
" " " " " " 9 " with excess brood - - -	3.83
" " " " " " 15 " " deficient " - - -	5.13

CONDITION OF BROOD IN RELATION TO DATE OF TREATMENT

Perhaps the most interesting thing brought out by this series of experiments is the variation in the effectiveness of the treatment as a control measure according to the date of treatment. An examination of the data suggests strongly a direct relation between the "souring" and the climatic conditions at the time of and following the time of treatment. This is especially striking when this data is used in the production of a graph. If temperature and rainfall records were available some definite conclusion might be drawn, but as to what climatic conditions were operative. It is, however, known that the twelve days following the treatment of August 18 was a period during which there were one or several light rains during every 24 hours period.

(times are totally lacking we can only guess

The accompanying sheets show graphically the brood condition in these trees treated at different dates and allow a comparison of the average attack, brood and brood deficiency in the S-series Trees and in standing infested trees.

CONCLUSIONS

In general the S-series of experiments allow us to draw the following tentative conclusions:-

1. Soon after treatment the sap in the treated trees undergoes a fermentation or souring or some similar change which is injurious to the young brood.

2. If the log contains more than average amount of sap and the climatic conditions following treatment are favorable the fermentation is violent enough to cause the early death of most of the brood.

3. When the sap contents are less than average or where the climatic conditions are not favorable such excessive fermentation does not occur and the brood varies from slightly below average to higher than average (average being the brood condition in standing trees of the same year).

4. The highest mortality occurred in trees where the treatment was followed by daily rains for a period of a week or more.

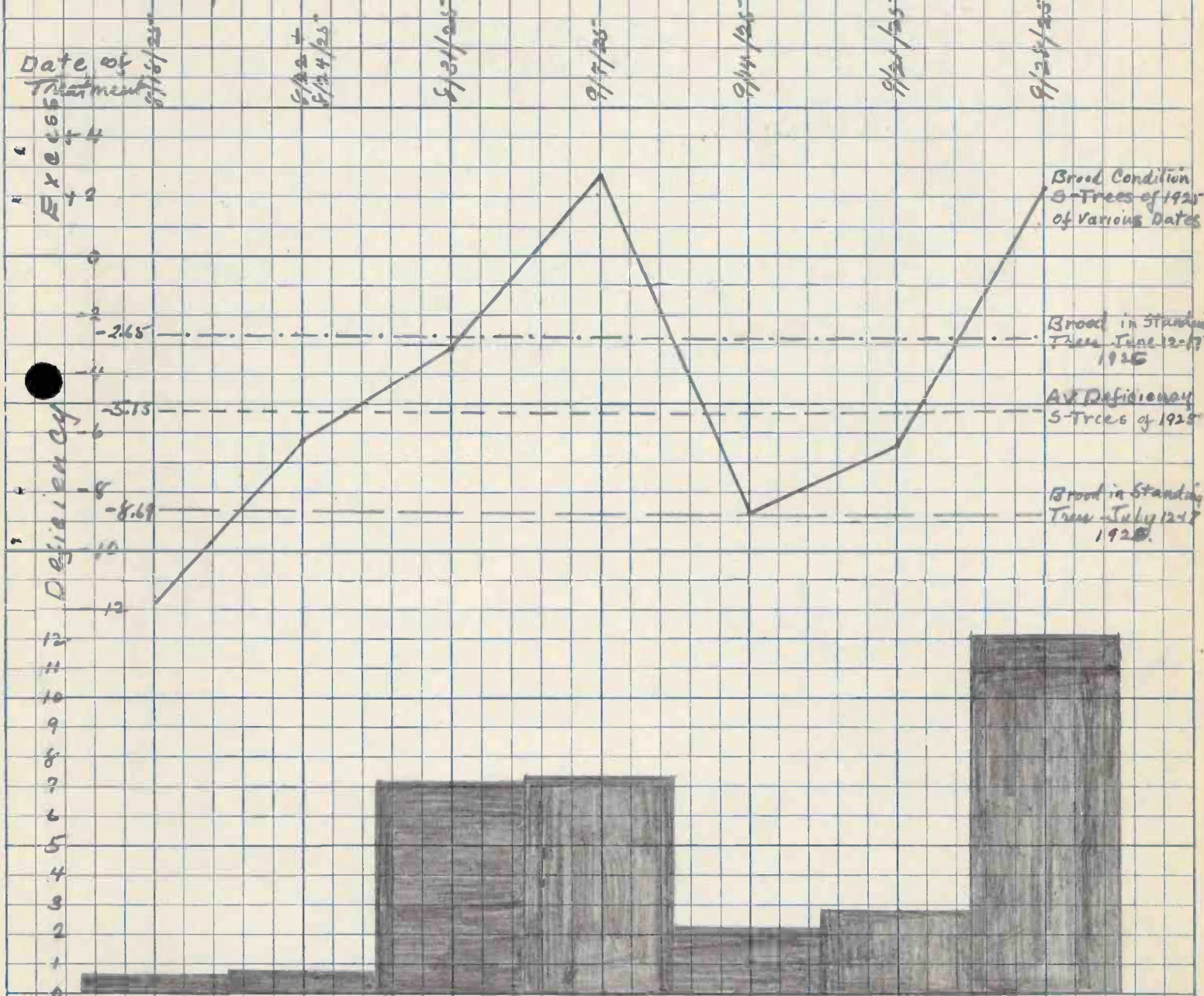
5. The greatest mortality of the brood was obtained in the trees earliest prepared. This may be due to the rainy weather immediately succeeding or may be on account of the greater length of time intervening between date of treatment and cessation of growth in the Fall.

6. The death of the larvae occurred during the few weeks between the time of treatment and cold weather. Most of the dead larvae were in larval mines from a half inch to 2 inches.

NAME DATE

Brood Condition Resulting from S-Treatment of Various Dates.

Date of Treatment	Area involved	Excess in Deficiency per sq. ft.
Aug. 18	313 sq. ft.	- 11.7 " " "
Aug. 22+24	357.5 " "	- 6.19 " " "
Aug. 31	662. " "	- 3.07 " " "
Sept. 7	343 " "	+ 2.72 " " "
Sept. 14	266.6 " "	- 8.70 " " "
Sept. 21	140. " "	- 6.44 " " "
Sept. 28	227.5 " "	+ 2.23 " " "



Average Brood per sq. ft. in S-Treatments of Various Dates

NAME DATE

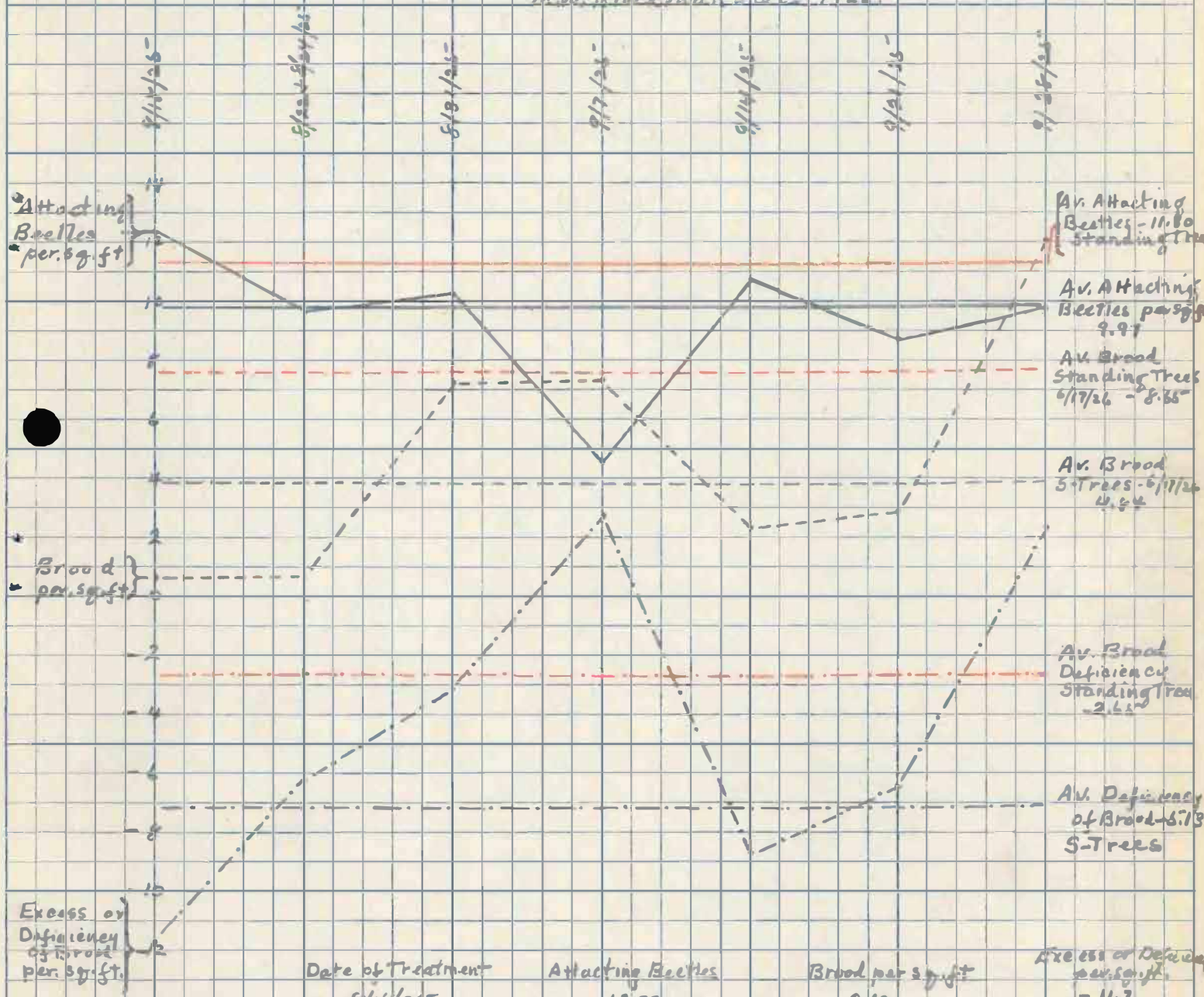
Average Attacting Beetles, Average Brood and Average Excess or Deficiency of Brood in 5-Treatments of Various Dates, 1925

in comparison with

Averages for Standing Infested Trees

Black Hills Beetle Kaibab N.F.

M.W. Blackman - Oct. 1926.


8/18/25
8/24/25
9/1/25
9/7/25
9/14/25
9/21/25
9/28/25
Attacting Beetles per sq ft
Brood per sq ft
Excess or Deficiency of Brood per sq ft.
Av. Attacting Beetles - 11.80 Standing Trees
Av. Attacting Beetles per sq ft 9.97
Av. Brood Standing Trees 6/17/26 - 8.35
Av. Brood 5-Trees - 6/17/26 4.64
Av. Brood Deficiency Standing Trees -2.65
Av. Deficiency of Brood - 5.13 5-Trees

Date of Treatment	Attacting Beetles	Brood per sq ft	Excess or Deficiency per sq ft.
8/18/25	12.32	0.62	-11.7
8/24/25	9.69	0.77	-6.11
9/1/25	10.25	2.19	-3.07
9/7/25	4.63	7.30	+2.72
9/14/25	10.86	2.28	-5.70
9/21/25	8.7	2.87	-6.44
9/28/25	9.65	12.04	+8.23

II. BUTT LOG CUT OUT AND COVERED WITH BRUSH.

BRUSH COVERED TREES

In September 1924 a number of infested trees at Mile-and-a-Half were felled, the infested length cut out and covered with brush. Examination of trees of this treatment during the following July and August (1925) showed the heaviest brood as to maximum brood per sq. ft., average brood per tree and average brood of all trees treated. 98 sq. ft. from several trees showed an average brood of 21.13 per sq. ft. and in 4 sq. ft. from one tree an average brood of 143 was obtained.

The results were so interesting that in August 1925 nineteen trees were felled and a butt-log of from 16-24 feet cut out. Ten of these were covered with branches as the previous year and nine were enclosed in a screen cage and covered with branches. This variation in the treatment was intended primarily to determine the efficiency of cerambycid larvae in destroying the bark beetle brood. The covered logs were designated as the C-series of experiments and the caged and covered logs as the T-C series.

C - Series Experiments

In this treatment ten trees varying from 10 to 20 inches D.B.H. average 14.9 and an average infested length of 34.2 were felled August 18 to 24, 1925, the basal 16 to 24 feet (average 19.6') cut out and covered with brush. These trees were examined by peeling the entire bark July 22 and 23, 1926. The area inside bark measured, the number of cerambycids counted, the number of attack and brood counted. This data and the computations there-from are given in the accompanying table.

At the time of examination close to 5% of the brood was in the pupal stage, a considerable number in the prepupal stage of full grown larvae, another considerable percentage of young adults, with indications of a small emergence, and a few were larvae smaller than half grown. These latter had without doubt developed from eggs laid since winter, although most of the brood, except where the sun reached the tops of the log was considerably retarded. The results of the treatment, aside from the retardation of most of the brood, were not at all comparable with those obtained the preceeding year, as the average brood was only 4.02 per sq. ft. which is perhaps no higher than the average brood in the same stage of development in untreated trees. Only a single one of the logs showed more brood than beetles attacking and the ten logs showed an average deficiency of brood over attack of 6.50 per sq.ft.

G. SERIES TREATMENTS

Mile and a Half, Kaibab, N. F. - Aug. 1925.

Cyrambycidae	No.	Infested	Length treated	Crown	Increment	DBH	Sq. Ft. Treated	Attacking Beetles	Brood	Excess or deficiency	Per Square Foot: Beetles attacking	Per Square Foot: Brood	Per Square Foot: Excess or deficiency
0	C-1	45'	18'	-	15	15"	54	315	630	338	-292	5.83	11.66	6.26	-5.40
0	C-2	-	18'	Med.heavy	16	13"	49	299	598	209	-389	6.10	12.20	4.26	-7.94
0	C-3	40	18'	" "	10	19"	78	414	828	116	-712	5.31	10.61	1.49	-9.12
0	C-4	30	18'	" "	-	16"	59	335	670	65	-605	5.68	11.36	1.10	-10.26
0	C-5	32	18'	" light	20	10"	36	216	432	47	-385	6.00	12.00	1.31	-10.69
5	C-6	45	18'	heavy	9½	20"	81	396	792	89	-703	4.88	9.77	1.09	-8.68
0	C-7	32	18'	M.Light	44	13"	51	253	506	243	-263	4.96	9.92	4.76	-5.16
1	C-8	30	24'	" "	11	15"	76	413	826	310	-516	5.43	10.86	4.08	-6.78
6	C-9	32	24'	" "	17	16"	76	298	596	461	-135	3.92	7.84	6.06	-1.78
0	C-10	22	22'	" "	42	12	48	261	522	571	+49	5.44	10.88	11.89	+1.01
12 Totals	308	196'			184	149	606	3200	6400	2449	-3951				
1.2 Averages.	34.2	19.6	Med.		20.4	14.9	60.8	320.0	640.0	244.9	-395.1	5.26	10.52	4.02	-650

III. BUTT LOG CUT OUT, CAGED AND COVERED WITH BRUSH.

T C -Series Experiments.

In these experiments nine trees of an average diameter of 15" and an average infested length of 54.33' were cut August 18-24, 1925, and from 16 to 24 feet of the lower trunk cut out. This cut out log was covered with wire screening in such a way as to exclude the long horned beetles from ovipositing in the bark and the caged log was then covered with brush. The brush and cages were removed July 22 and 23, 1926, the bark all stripped off the area i.e. computed and accurate counts made of attack, barkbeetle brood and cerambycid larvae.

The stages represented in the brood was about as in the C treatment. The number of attacks per sq. ft. was about the same but the brood was more than twice as numerous. Even with this heavier brood, however, only three trees showed a surplus of brood over attack and there was an average deficiency of 2.54 per square foot in the nine trees treated.

The experiment was a failure in the purpose for which it was planned, i.e. to compare the brood in caged logs having no cerambycids with that in uncaged logs having many cerambycid larvae. The logs of neither treatment contained many round heads and the number of round head larvae in each treatment was identical. This means that although the logs were treated as early as was thought safe (Aug. 18-24) some cerambycids had already oviposited in them and the two treatments happened to show exactly the same number of larvae.

However, if we compute the attacks and brood in trees with round headed borers and in those without them we obtain the following data:-

Total Sq. ft. infested	1130
Total attacks in 19 trees (C & T C -series)	5997
Attacking beetles " " " " "	11994
Total brood " " " " "	6715
Deficiency of brood " " " "	5279

Average attacks per sq. ft.	5.30
" beetles attacking per sq. ft.	10.61
" brood per sq. ft.	5.94
Deficiency " " "	4.67

Average attacks per sq.ft. in logs with cerambycid larvae	4.65
" attacking beetles " " " "	9.31
" brood " " " "	4.70
" deficiency " " " "	4.61
Average attacks per sq.ft. in logs with no cerambycid larvae	5.46
" Attacking beetles " " " "	10.93
" brood " " " "	6.36
" deficiency " " " "	4.57

This small difference may, however, be only accidental owing to the fact that two especially heavily brooded trees happened to fall in one class. The computations are based on too small data to be of much value. In any event the differences in the two classes of trees is too small to be of any particular significance.

T-C SEWING TREATMENTS

Mile and a Half, Kaibab N.F. Aug. 1925.

Cyram-bycidas	No.	Infested	length treat- ed	Crown	Increment	DBH	Sq. Ft. Treated	Attacking	Beetles	Brood	Excess or deficiency	Attacking	Per Square Foot Beetles attacking	Brood	Excess or deficiency
12	TC-1	30'	16'	M.Heavy	16	15"	53	275	550	496	-54	5.19	10.38	9.17	-1.21
0	TC-2	40'	18'	-	6½	15"	56	362	724	155	-589	6.46	12.92	2.41	-10.51
0	TC-3	50'	10'	M. Heavy	12	18"	75	382	764	221	-543	5.09	10.18	2.94	-7.24
0	TC-4	45'	18'	" "	11	16"	66	333	666	472	-194	5.04	10.09	7.15	-2.94
0	TC-5	17'	16'	Heavy	8	12"	45	250	500	838	+338	5.55	11.11	18.62	+7.51
0	TC-6	24'	18'	M. "	15	14"	51	316	632	169	-463	6.19	12.39	3.31	-9.08
0	TC-7	40'	16'	" "	19	16"	50	265	530	96	-434	5.30	10.60	1.92	-8.68
0	TC-8	30	18'	M.Light	16	12	46	200	400	965	+565	4.16	8.33	20.10	+11.71
0	TC-9	35	24	Light	39	17	78	414	828	884	+56	5.31	10.62	11.33	+0.72
12 Totals		309	164	Heavy	144.5	135	522	2797	5594	4266	-1328				
1.33 Averages		34.33	18.22	M.H.	16.06	15.	58'	311	622	467.3	-147.55	5.35	10.71	9.17	-2.54